CLAIMS

1. A heating element, comprising:

first and second bus plates, and

a plurality of positive temperature coefficient elements in electrical contact with, and sandwiched between the bus plates in an electrically parallel configuration, each positive temperature coefficient element including:

first and second conductive plates, and

a plurality of positive temperature coefficient heating stones in electrical contact with, and sandwiched between the conductive plates in an electrically parallel configuration.

2. The heating element of claim 1 wherein the heating element further comprises first and second thermally conductive and electrically insulative pads positioned, respectively, in face to face contact with the first bus plate on a side opposite the plurality of positive temperature coefficient elements, and in face to face contact with the second bus plate on a side opposite the plurality of positive temperature coefficient elements.

3. A fluid heater, comprising:

a first heat exchanger block having a first surface; and

a heating element having a second surface in thermal contact with the first surface, the heating element including first and second bus plates and a plurality of positive temperature coefficient elements in electrical contact with, and sandwiched between the bus plates in an electrically parallel configuration, each positive temperature coefficient element including:

first and second conductive plates, and

a plurality of positive temperature coefficient heating stones in electrical contact with, and sandwiched between the conductive plates in an electrically parallel configuration.

4. The fluid heater of claim 3, further comprising a cavity formed in the first surface, in which the heating element is positioned.

5. The fluid heater of claim 3, further comprising a fluid heating tube within the first heat exchanger block.

6. The fluid heater of claim 3 wherein the heating element further includes a third surface, the fluid heater further comprising a second heat exchanger block having a fourth surface, the second heat exchanger block positioned such that the fourth surface is in thermal contact with the third surface.

7. The fluid heater of claim 6, further comprising a fluid heating tube within the second heat exchanger block.

8. The fluid heater of claim 6, further comprising a depression formed in each of the first and fourth surfaces, the depressions of the first and fourth surfaces together forming a cavity in which the heating element is positioned.

9. The fluid heater of claim 8 wherein the first and fourth surface are in face-to-face contact.

10. A fluid heater, comprising:

a first heat exchanger block having therein a fluid heating tube, the first block having a first surface;

a second heat exchanger block having therein a fluid heating tube, the second block having a second surface, and the second block positioned, relative to the first block, such that the first and second surfaces are adjacent to each other;

a cavity formed in the first surface, the cavity having a third surface on an inner face thereof; and

a heating element having fourth and fifth surfaces on opposing sides thereof positioned within the cavity with the fourth surface in face to face contact with the third surface and the fifth surface in face to face contact with the second surface, the heating element being encapsulated within the cavity.

11. The fluid heater of claim 10 wherein the heating element comprises:

first and second bus plates; and

a plurality of positive temperature coefficient elements in electrical contact with, and sandwiched between the bus plates in an electrically parallel configuration.

12. The fluid heater of claim 11 wherein each of the positive temperature coefficient elements comprises first and second conductive plates and a plurality of positive temperature coefficient heating stones in electrical contact with, and sandwiched between the conductive plates in an electrically parallel configuration.

13. The fluid heater of claim 11 wherein the heating element further comprises first and second thermally conductive and electrically insulative pads positioned respectively between the first bus plate and the first surface and between the second bus plate and the third surface.

14. The fluid heater of claim 10, further comprising:

an aperture in the first heat exchanger block communicating from the cavity to an outer surface of the first block;

an electrical power supply cable coupled at a first end to the heating element and passing through the aperture such that a second end of the cable lies outside of the first block; and

an explosion proof seal closing the aperture around the cable.

15. The fluid heater of claim 10 wherein the first and second surfaces are spaced a selected distance apart.

16. A fluid heater, comprising:

a first heat exchanger block having therein a fluid heating tube, the first block having a first surface;

a second heat exchanger block having therein a fluid heating tube, the second block having a second surface, and the second block positioned, relative to the first block, such that the first and second surfaces are adjacent to each other;

a first cavity formed in the first heat exchanger block in the first surface;

a second cavity formed in the second heat exchanger block in the second surface, the second cavity positioned such that, when the first and second surfaces are in face to face contact, the first and second cavities are opposite one another and form a chamber between the first and second blocks; and

a heating element positioned within the chamber.

17. The fluid heater of claim 16 wherein the first surface is non-planar and the second surface is configured to conform to the non-planar first surface.

18. The fluid heater of claim 16, further comprising means for equalizing pressure between the chamber and the outside of the fluid heater.

19. The fluid heater of claim 16 wherein a shape of the chamber conforms to a shape of the heating element.

20. A fluid heater, comprising:

a heating element having first and second surfaces on opposing sides thereof, the heating element including:

first and second bus plates, and

a plurality of positive temperature coefficient heating elements in electrical contact with, and sandwiched between the bus plates in an electrically parallel configuration, each positive temperature coefficient element including:

first and second conductive plates, and

a plurality of positive temperature coefficient heating stones in electrical contact with, and sandwiched between the conductive plates in an electrically parallel configuration;

a first heat exchanger block having a fluid heating tube therein, the first block having a third surface;

a second heat exchanger block having a fluid heating tube therein, the second block having a fourth surface; and

the first and second blocks and the heating element positioned such, that the first and second surfaces are in face to face contact with the third and fourth surfaces, respectively, with the heating element sandwiched therebetween.

21. The fluid heater of claim 20 wherein:

the first heat exchanger block includes a fifth surface lying in a plane parallel to the third surface and a first selected distance therefrom;

the second heat exchanger block includes a sixth surface lying in a plane parallel to the fourth surface and a second selected distance therefrom;

the first block is configured such that the third surface constitutes a back wall of a cavity formed in the fifth surface, the cavity configured such that, when the first and second surfaces are adjacent to the third and fourth surfaces, respectively, the fifth surface is adjacent to the sixth surface, encapsulating, thereby, the heating element.

22. The fluid heater of claim 21 wherein the second selected distance is zero, such that the second and sixth surfaces are the same surface.

23. The fluid heater of claim 21 wherein the second selected distance is greater than zero, such that the second surface constitutes a back wall of a cavity formed in the sixth surface.

24. The fluid heater of claim 20 wherein the heating element further comprises first and second thermally conductive and electrically insulative pads positioned, respectively, between the first bus plate and the third surface and between the second bus plate and the fourth surface.

25. The fluid heater of claim 20 wherein the heating element further comprises an alignment mask sandwiched, with the plurality of positive temperature coefficient elements, between the first and second bus plates, the alignment mask including a plurality of cutouts evenly spaced along a length thereof, and wherein each of the plurality of positive temperature coefficient elements is positioned within a corresponding one of the plurality of cutouts, the alignment mask formed from an electrically nonconductive and compressible material.

26. The fluid heater of claim 20 wherein:

the first heat exchanger block includes a recess in the third surface;

the fluid heater further comprises an alignment pin positioned within the recess such that a first end of the pin extends from the recess generally perpendicularly to the third surface; and

the first and second bus plates of the heating element include respective alignment notches positioned such that, when the heating element is correctly positioned between the third and fourth surfaces, the respective alignment notches of the first and second bus plates engage the alignment pin.

27. The fluid heater of claim 20, further comprising a plate having fifth and sixth surfaces on opposite sides thereof and an aperture, passing from the fifth to the sixth surface, of a size sufficient to encompass the heating element, the plate positioned such that the fifth surface is adjacent to the third surface and the sixth surface is adjacent to the fourth surface, with the heating element encapsulated within the aperture of the block and between the third and fourth surfaces.

28. The fluid heater of claim 20 wherein the third and fourth surfaces are non-planar and configured to mate with the fifth and sixth surfaces of the plate, respectively.

29. A method for heating a fluid, comprising:

introducing a fluid into a first end of a first tube encased in a first block of thermally conductive material having a surface;

extracting the fluid from a second end of the tube;

introducing the fluid into a first end of a second tube encased in a second block of thermally conductive material having a surface, the first and second blocks arranged such that the respective surfaces are adjacent; and

applying a voltage to a heating element encapsulated in a cavity between the first and second blocks, thereby:

heating the element, the thermally conductive material of the first and second blocks in contact therewith, and the first and second tubes, and

heating the fluid.

30. The method of claim 29 wherein heating the first and second tubes comprises heating the first and second tubes to a temperature exceeding the saturation temperature of the fluid, and wherein heating the fluid comprises vaporizing the fluid.

31. The method of claim 30 wherein the fluid is a liquefied gas.

32. The method of claim 29 wherein the heating element comprises first and second bus plates and a plurality of positive temperature coefficient elements in electrical contact with, and sandwiched between the bus plates in an electrically parallel configuration, each positive temperature coefficient element including first and second conductive plates and a plurality of positive temperature coefficient heating stones in electrical contact with, and sandwiched between, the conductive plates in an electrically parallel configuration.